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Title: Investigation Of Thermospheric And Ionospheric Changes During Ionospheric Storms With Satellite And Ground-Based Data And Modeling

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Annual Performance Report:

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Period of Performance: 03/15/00 to 03/14/01

The purpose of this proposed research is to improve our basic understanding of the causes of ionospheric storm behavior in the midlatitude F region ionosphere. This objective will be achieved by detailed comparisons between ground based measurements of the peak electron density ($N_m F_2$), Atmosphere Explorer satellite measurements of ion and neutral composition, and output from the Field Line Interhemispheric Plasma (FLIP) model. The primary result will be a better understanding of changes in the neutral densities and ion chemistry during magnetic storms that will improve our capability to model the weather of the ionosphere which will be needed as a basis for ionospheric prediction. Specifically, this study seeks to answer the following questions

- 1) To what extent are negative ionospheric storm phases caused by changes in the atomic to molecular ratio?
- 2) Are the changes in neutral density ratio due to increased N_2 , decreased O , or both?
- 3) Are there other chemical processes (e.g. excited N_2) that increase O^+ loss rates during negative storms?
- 4) Do neutral density altitude distributions differ from hydrostatic equilibrium?
- 5) Why do near normal nighttime densities often follow daytime depletions of electron density?
- 6) Can changes in $h_m F_2$ fully account for positive storm phases?

To answer these questions, we plan to combine ground-based and spaced-based measurements with the aid of our ionospheric model which is ideally suited to this purpose. The ionosonde data provide a means of determining the extent of the day-to-day changes in the electron density while the satellite provides the details of the neutral and ion densities and temperatures. The model provides a means of linking the measurements together in space and time. The viability of this approach has been demonstrated by a preliminary analysis of a sample data set.

These proposed studies will lead to a better capability to predict long term ionospheric variability, leading to better predictions of ionospheric weather. Also, if differences between the measured and modeled $N_m F_2$ are shown to be related to problems with the neutral density model, our studies could also lead to improved thermospheric models.

Progress

In the first year of this grant we have developed and refined our FLIP model algorithms that use data as constraints. We have applied these algorithms in a comparison with ion and electron density data from the AE-C satellite for September 15, 1974. Figure 1 shows a FLIP model simulation of the September 12-19, 1974 period at Hobart (43S, 147E). A magnetic storm occurred on September 15 just prior to an AE-C overflight. The dashed lines are for a standard FLIP run with no modification of the MSIS neutral densities. The dots are ionosonde measurements. Figure 1a shows that the standard FLIP model is in excellent agreement with the measurement except on the disturbed days of September 15 and 16 where the model daytime densities are too high. The model was then run with modified MSIS temperature modifi-

cation algorithm. This run shows that the temperatures are much larger on the disturbed days than are predicted by MSIS.

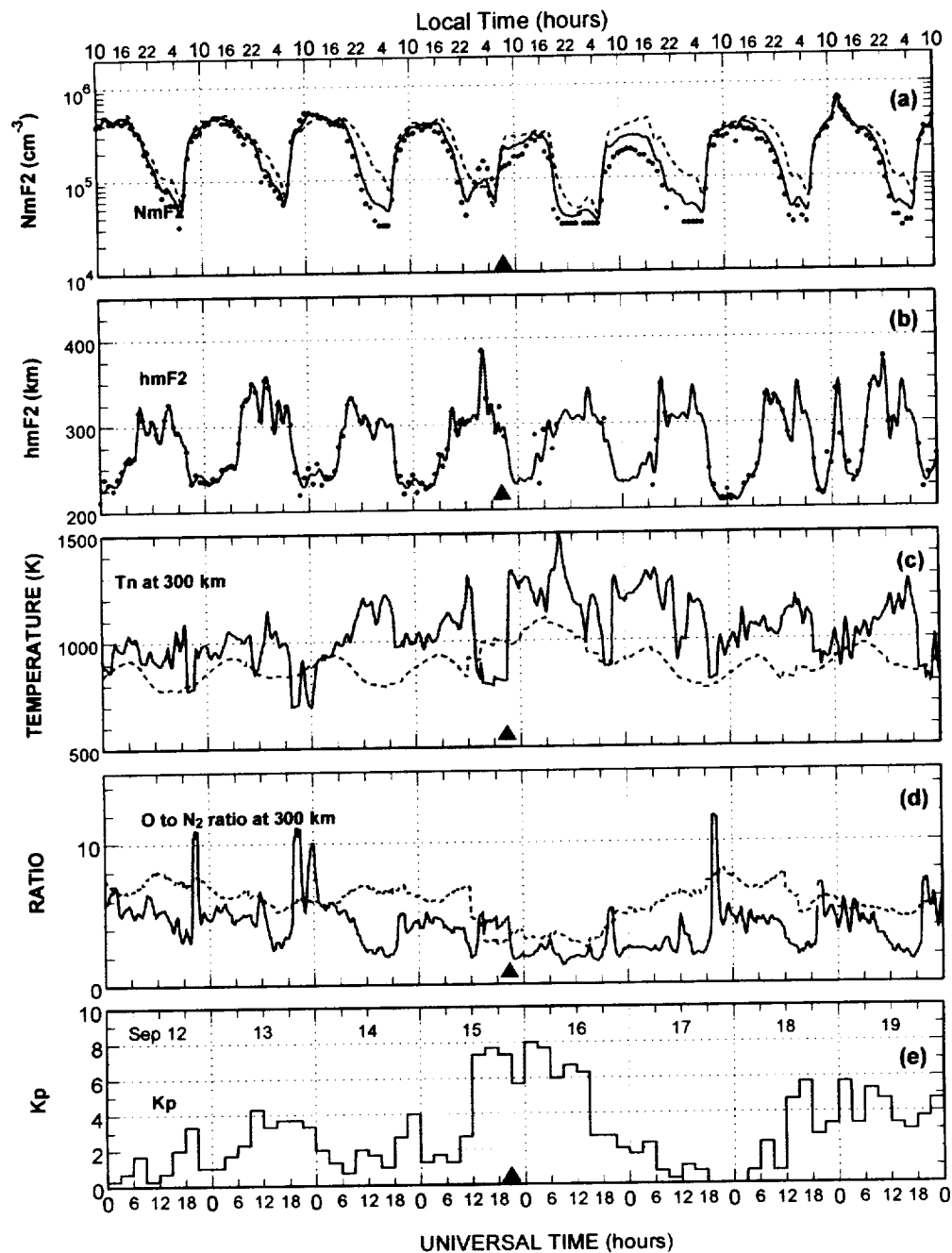


Figure 1. FLIP model simulation of the peak electron density at Hobart in September, 12, 1974. The triangles indicate the time of the AE-C overflight.

Figure 2 shows a comparison of the Hobart modeled and measured electron and ion densities for the time of the satellite overflight on September 15. This Figure shows that the satellite electron density is in good agreement with the ionosonde peak electron density at 250 km,

but the model is still 30% high even with the neutral density modification. Although the neutral temperature has brought the model into better agreement at the peak it is still 30% higher than the measured peak density in the region of the peak at 250 km. The model ion density altitude profiles differ from the measurements. The main point of interest is that the measured O^+ density is depleted above 200 km while the NO^+ density is enhanced. We are now investigating whether the densities are consistent with the effect of vibrationally excited N_2 on the $O^+ + N_2 \rightarrow NO^+ + N$ reaction rate.

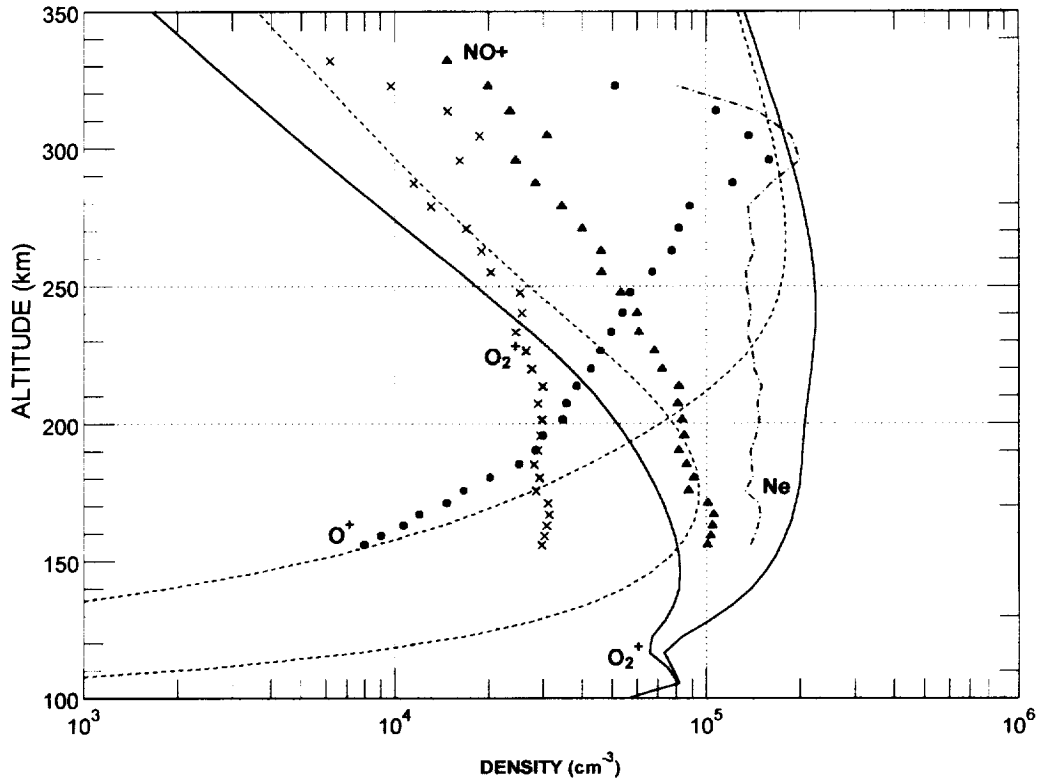


Figure 2. Comparison of AE-C measured and modeled electron and ion densities for 2300 UT on September 15, 1974. The lines are from the FLIP model while the symbols are data.

Figure 3a shows a comparison of the MSIS model densities with the AE-C measurements. This shows that the measured atomic oxygen density is substantially lower than the MSIS model, even when the density is modified by the FLIP model to bring the model electron density into agreement at the peak. On the other hand, Figure 3b shows that the modified FLIP model neutral temperature agrees well with measured ion temperature. The low O density helps to explain why the FLIP model electron density is too high; the O^+ production rate is too high. Further modifications to the FLIP model neutral density algorithm are needed to bring the O density into line with the measurements.

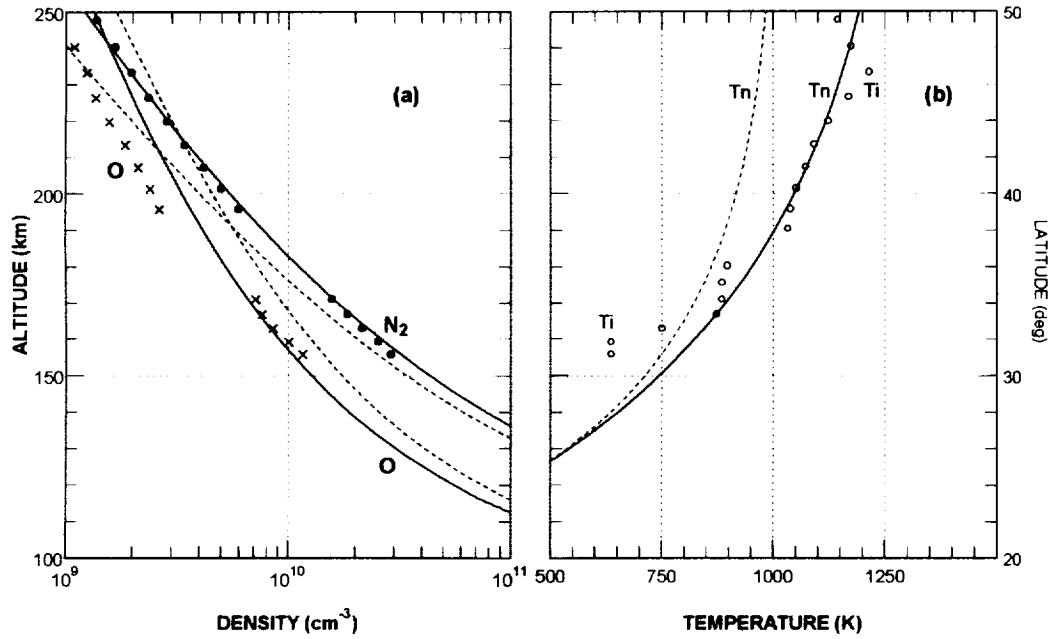


Figure 3. Comparison of measured values with model values at Canberra (35S,149E) just before 2400 UT on September 15. Dashed lines are from the standard MSIS model. Solid lines are from the modified MSIS model. The measurements are crosses (O), dots (N_2), open circles (Ti). Approximate latitude (south) is given on the rightmost Y axis.

Plans for Second year

We plan to complete the study of the September 15 event and publish the results in the coming year. These initial results indicate that some improvement to the FLIP model algorithms will be needed to bring the model NmF2 into better agreement with the data. When the September 15 event is complete we will begin studies of other events that were captured by AE-C.